

GROUNDWATER EXPLORATION AND DEVELOPMENT: A CASE STUDY FOR COBB COUNTY-MARIETTA WATER AUTHORITY

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Abstract. The Cobb County-Marietta Water Authority (CCMWA) has taken a bold approach to developing new sources of water supplies to meet peak water supply demands. We have completed the first phase of a county-wide groundwater investigation which identified 33 areas considered hydrogeologically favorable for developing groundwater resources. The yield from these zones is estimated to be 10 to 15+ million gallons per day. Recently, two wells were drilled in a single favorable zone identified as MOU-3; combined, these wells yielded 900,000 gallons per day meeting all EPA Primary and Secondary Drinking Water Standards. The cost of developing these groundwater resources is anticipated to be one-third to one-half of that for developing alternative surface water supplies.

INTRODUCTION

Water supplies currently used for public consumption in the Greater Atlanta Region are derived almost exclusively from surface water sources such as rivers, streams, and impoundments. However, projections for future water needs in the Greater Atlanta Region have caused great concern among present public water authorities regarding their ability to meet future anticipated water demands. So where will the water come from? According to the Georgia Department of Natural Resources (DNR), some of the supply will have to come from groundwater resources and from conservation (State of Georgia, Water Resources Management Strategy, Appendix B, June 1990).

In light of anticipated water demand increases, the increased competition for surface water resources, and the time delays and costs associated with developing new surface water supplies, the Cobb County-Marietta Water Authority investigated the potential for developing groundwater resources within the County to supply water during peak water demand periods. We conducted a County-wide hydrogeologic investigation to identify zones considered favorable for developing potable groundwater resources within Cobb County's geographical borders. This investigation identified 33 areas dis-

tributed throughout the County which are considered to be hydrogeologically favorable for developing 10-15+ million gallons per day (gpd) of groundwater resources from fractured bedrock aquifers.

This document gives the results of drilling test wells, pumping tests, and water quality analyses conducted in the first of these 33 zones.

GROUNDWATER EXPLORATION APPROACH

Our approach to groundwater exploration and development is based upon understanding the geologic environment from which groundwater resources are withdrawn, using aerial photography, detailed bedrock mapping, bedrock fracture fabric data, geophysical analyses, and in situ hydrogeologic testing.

The exploration effort involves a continual focusing process, beginning with the entire area available for study (i.e., County), narrowing down the investigation area to favorable zones suitable for groundwater development, and finally selecting specific well drilling targets. This leads to the successful drilling of wells in terms of yield and quality and is accomplished by locating water-bearing zones (i.e., bedrock fracture zones) that are interconnected, laterally extensive, and can be predictably intercepted when drilling, thus eliminating the "wildcatting" aspects of groundwater development.

TEST WELL DRILLING

Preliminary geologic investigations identified 33 areas considered favorable for groundwater development within Cobb County. Two test wells, identified as well MOU-3/W-1 and well MOU-3/W-3, were drilled in the Mountain Park Zone #3 (MOU-3). This zone is located in the northeast quadrant of Cobb County. Both test wells were drilled in May/June of 1993 by Middle Georgia Water Systems (Zebulon, Georgia) using an Ingersoll-Rand T-4 drill rig equipped with a 900 cubic foot per meter (cfm) 305 pounds

per square inch (psi) air compressor. Well MOU-3/W-1 was drilled to a depth of 577 feet and intercepted bedrock at 86.5 feet below ground surface. Well MOU-3/W-3 was drilled to a total depth of 452 feet and intercepted bedrock at 18 feet below the ground surface.

Throughout the drilling program, rock chips were collected by on-site geologists at 10-foot intervals and at lithologic changes so that an accurate geologic log of the borehole could be prepared. In general, the rock types encountered during drilling included biotite gneiss interlayered with muscovite schist and amphibolite. Both test wells yielded water of sufficient yield and quality to warrant additional investigation at this site.

CONVERSION OF TEST WELLS TO PRODUCTION WELLS

Test wells MOU-3/W-1 and MOU-3/W-3 were reamed from 6 inches in diameter to 8 inches in diameter for the following reasons:

- The larger diameter well provides greater flexibility in pump selection (i.e., large diameter pumps with slower rotation speeds can be used, thereby minimizing wear and tear on the pump and pumping equipment).
- Increasing the diameter of a well often leads to increased yield and well efficiency.
- The larger-diameter wells reduce the entrance velocity of water entering the borehole from bedrock fracture zones, thereby reducing the degree to which mineral precipitates will form on the pump and borehole surface.
- Larger diameter wells provide a greater annular space for pump clearance, reducing the potential for pumps in the well to become lodged.

Reaming of these wells resulted in substantially increasing their yields. Enlarging the diameter of well MOU-3/W-1 improved its yield from 180 gpm to 360 gpm; the yield of well MOU-3/W-3 improved from 260 gpm to 500 gpm.

PUMPING TEST PROGRAM

Results of the Pumping Tests

A multiple phased pumping test program was implemented to evaluate the productivity of wells MOU-3/W-1 and MOU-3/W-3. The ultimate goal of a groundwater exploration program is to develop sustainable, high quality water supplies. The results of the pumping test program conducted at the Mountain Park Zone #3 site included the following:

- The long-term sustainable pumping capacity (yield) of wells MOU-3/W-1 and MOU-3/W-3 was determined to be 900,000 gpd.
- The quality of groundwater under long-term pumping conditions meets all EPA Safe Drinking Water Standards.

Pumping Test Design

For the purposes of this groundwater supply development program, a three-phase design for the pumping test was selected. The first phase included short term "step" drawdown tests on both the production wells. Step tests require that a well be pumped at a number of incrementally higher pumping rates, each for a pre-determined amount of time. For each well, EGGI extended the last step to observe the performance of the well at the highest pumping rate. During each step, the pumping rate was held constant.

Short-term step tests were followed by long-term (3 day) constant rate pumping tests. During long-term pumping tests, water levels in both pumping wells and the selected on-site monitoring well were recorded to the nearest .01 foot. Immediately after pumping each well, recovery water levels were recorded in each well until pre-pumping water levels were re-established.

Wells MOU-3/W-1 and MOU-3/W-3 were pumped simultaneously, with minor offsets in starting time for logistical reasons. In Georgia, constant rate tests are required to continue for a minimum of 24 hours for public water supplies; however, for this project, pumping tests were extended for 73 consecutive hours to more fully stress the bedrock aquifer system. By pumping both wells simultaneously, future operational usage was simulated.

Step Drawdown Response in Well MOU-3/W-1

The step drawdown test performed on pumping well MOU-3/W-1 was conducted on February 10, 1994, beginning at 11:00 AM and ending at 6:30 PM. The test consisted of six discrete steps, the first five steps lasting 1 hour each and the last step running 2.5 hours. The initial pumping rate for step one was 100 gpm, followed by pumping rates of 153, 196, 256, 296, and 335 gpm. The final drawdown observed in this well at the end of pumping the last step was 126.03 feet.

Specific capacity is a measure of the productivity of a well and is defined as the pumping rate per foot of drawdown in the pumping well reported in gallons per minute (gpm) per foot of drawdown (gpm/ft). Specific capacities are a measure of well efficiency and therefore, productivity. During the step test, the specific capacity showed a steady decrease from 4.3 gpm/ft in step 1 to 2.83 gpm/ft in step 4. During step 5, a rise in water levels was observed as indicated by an increase in specific capacity to 3.19 gpm/ft. This phenomenon is unexplainable at this time. As the discharge rate was increased for step 6, the specific capacity decreased again to 2.65 gpm/ft, as would be expected. The steady decrease in specific capacity throughout the test, excluding step 5, is attributed to well inefficiencies (due to increased turbulence in the well bore) caused by progressively high pumping rates. The increased specific capacity observed in step 5 may represent a temporary state of increased efficiency resulting from the unique geometry of the water-bearing fracture zones. Based upon the step test data collected, a pumping rate of 290 gpm was chosen for the long-term pumping test.

Step Drawdown Response in Well MOU-3/W-3

A step drawdown test was also performed on well MOU-3/W-3 on February 10, 1994, beginning at 10:00 AM and concluding at 6:30 PM. The test consisted of eight discrete pumping steps: seven, one hour steps and a final step of 1.5 hours. Pumping rates varied from 155 gallons per minute to 196, 244, 300, 327, 394, 450, consecutively and concluded at step #8 at 514 gpm. The final drawdown in the well at the end of the step test was 240.12 feet.

Specific capacities gradually decreased from 3.73 to 2.14 gpm/ft with increased pumping rates. Based upon the hydro-geologic data collected during this step test, the recommended pumping rate for the long-term pumping test was chosen at approximately 345 gpm.

Well MOU-3/W-1 -- Extended Pumping Test

Wells MOU-3/W-1 and MOU-3/W-3 were pumped simultaneously for a period of 73 continuous hours to determine the maximum safe yield of the aquifer (Table 1). MOU-3/W-2 served as a monitoring well throughout the pumping test period. In-field and laboratory samples were collected periodically throughout the 73-hour pumping test.

Well MOU-3/W-1 began pumping at 12:00 noon on February 11, 1994, at an average of 290 gallons per minute. A plot of time verses water levels (Figure 1) shows that drawdown continued steadily in this well at the start of the test, but gradually began to stabilize at approximately 2500 to 3000 minutes into the test. Stabilization is shown as flattening of the curve because the cone of depression created by the pumping well has expanded far enough into the bedrock aquifer to collect sufficient recharge to equal the pumping rate.

The total drawdown recorded in this well at the conclusion of pumping was 186.43 feet (Table 1) which resulted in a specific capacity of 1.55 gpm per foot (gpm/ft) of drawdown at 290 gpm. The continuous 73 hour pumping test utilized only 68% of the available drawdown in the well. The maximum recommended drawdown for this well is 276 feet which is where the first major water-bearing fracture zone was intercepted in the borehole. Projecting the drawdown curve over pumping time shows a drawdown level of less than 200 feet after 180 days of pumping.

The recovery of MOU-3/W-1 following the termination of pumping occurred very quickly. Within 68% of the total pumping time, MOU-3/W-1 attained over 99% recovery (Figure 1).

Well MOU-3/W-3 -- Extended Pumping Test

The pumping test on MOU-3/W-3 began on February 11, 1994 at 12:00 PM and continued uninterrupted for 73 hours, pumping at 335 to 340 gpm. Well MOU-3/W-3 was flowing at 5-7 gpm at the start of the test and at the end of the 73 hour pumping test the water level was drawn to 203.59 feet below the top of casing. The specific capacity of the well was calculated to be 1.67 gpm/ft.

The recovery of MOU-3/W-3 was extremely rapid for the first 300 minutes after pumping stopped. Within 60% of the

Table 1. Summary of Long-Term Pumping Test Results for Wells at Mountain Park Site

Well (purpose)	Avg. Pumping Rate (gpm)	Maximum Drawdown (feet)	Specific Capacity (gpm/ft)	Pumping Test Duration (hours)
MOU-3/W-1 (pumping)	290	186.43 32%* remaining	1.55	73
MOU-3/W-2 (monitoring)	NA	21.94	NA	NA
MOU-3/W-3 (pumping)	340	203.59 23%* remaining	1.67	73

NA = Not Applicable

*Percentage of available drawdown based on the location of a major water-bearing bedrock fracture zone.

total pumping time, well MOU-3/W-3 had fully recovered and was again flowing at 5-7 gpm over the top of casing.

WATER QUALITY ANALYSES

MOU-3/W-1 Water Quality

In-field and laboratory water quality results from samples collected during and at the conclusion of pumping indicate well MOU-3/W-1 produces water of excellent quality. Parameters including iron and manganese show extremely low or non-detectable levels. Sulfate and hardness values were also acceptable. No volatile organic compounds, pesticides, or bacteria were detected. Three sets of radon gas samples were collected at 4, 53.5 and 70.5 hours into the constant-rate pumping test. The test results show a trend of radon reduction from 1900 pCi/l to 1700 pCi/l over pumping time and

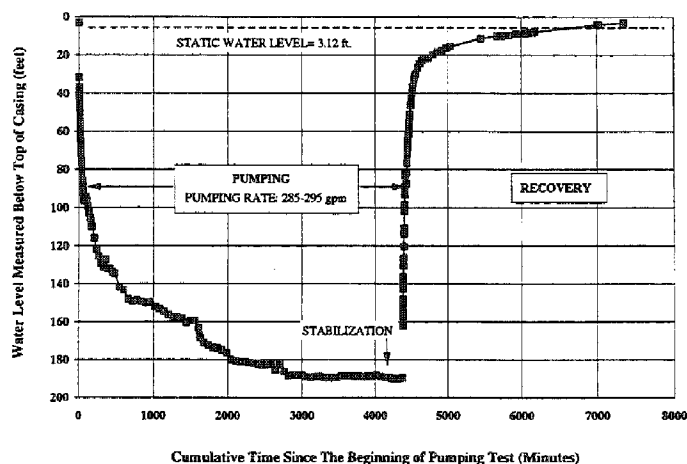


Figure 1. Plot of time versus water levels for Well MOU-3/W-1, Mountain Park Site, Cobb County, Georgia.

display a substantial reduction over the non-pumping value of 3300 pCi/l collected two days after the well was drilled. Overall, the water produced from this well meets all Primary and Secondary Drinking Water Standards as set forth by EPA's Safe Drinking Water Act including all revisions to date.

MOU-3/W-3 Water Quality

Water quality samples obtained from MOU-3/W-3 throughout and at the end of the pumping test indicate that this well also produces water of excellent quality. Iron and manganese levels reported from in-field and laboratory analyses show very low or non-detectable levels for both parameters. Sulfate and hardness levels were between 85-95 mg/l and 125 mg/l, respectively. No volatile organic compounds, pesticides, or bacteria were detected. Furthermore, a decrease in radon from 2100 pCi/l, 53 hours into pumping to 1300 pCi/l at the conclusion of pumping was observed. The water produced meets all Primary and Secondary Drinking Water Standards in accordance with EPA's Safe Drinking Water Act including all revisions to date.

CONCLUSIONS

Based on the results of the long-term pumping tests and the water-bearing characteristics of the bedrock aquifer in Mountain Park Zone #3, we conclude the following:

- The constant rate pumping test conducted at the Mountain Park site has demonstrated that Well MOU-3/W-1 can sustain a pumping rate of 290 gpm and well MOU-3/W-3 can sustain a rate of 335 gpm, for a combined yield of 625 gpm or 900,000 gpd.
- There was no sign during the pumping test of the draw-down cone intercepting a barrier or "no flow" boundary, which would result in causing the wells to decline in yield (Figures 1 and 2). Water levels projected out into

time show that critical drawdown levels (defined by the elevation of a significant water-bearing fracture zone) will not be reached, even after 180 days of pumping.

- Complete recovery of both wells within 70% of the total pumping time serves to further confirm that water is not being taken out of storage but that the fracture system is receiving adequate recharge to sustain the tested yield of each well.
- Water derived from both wells (MOU-3/W-1 and MOU-3/W-3) meets all Primary and Secondary Drinking Water Standards in accordance with EPA's Safe Drinking Water Act. Although regulated levels of radon have not yet been established by the EPA, it may be necessary to treat radon in the future using an on-site aeration system.
- A groundwater supply of 10 to 15+ million gallons per day is estimated to be available from fractured bedrock aquifers within the County. Estimated costs to develop potable groundwater resources in Cobb County range from \$.50 to less than \$1.00 per gallon per day of capacity developed. This is equivalent to one-third to one-half the cost of developing alternative surface water supplies.

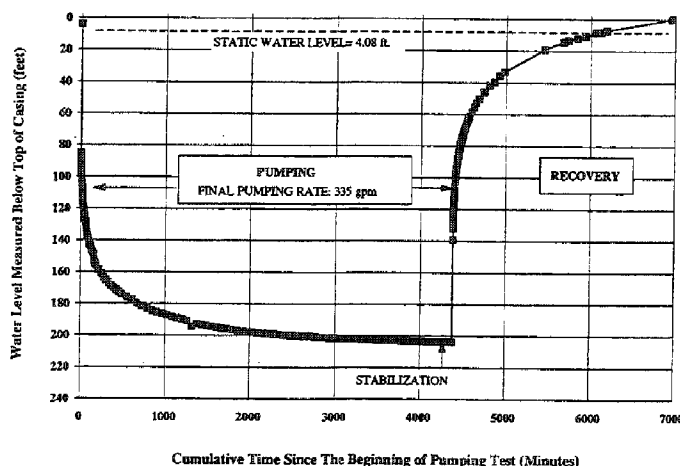


Figure 2. Plot of time versus water levels for Well MOU-3/W-3, Mountain Park Site, Cobb County, Georgia.